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ABSTRACT

The paper presented relates to the value of comparative studies in higher education. The problem discussed is one that transcends the country of origin: Germany. The publication is a translation of a paper delivered at the University of Karlsruhe in 1975 and speaks of the current dilemmas of science and engineering that are clearly universal. Engineering sciences in all fields of higher learning, but particularly in their relationship to the humanities are discussed. University systems outside Germany that are compared include the American, French, British, Soviet, and the Japanese. A summary evaluation of the current state of engineering science is included. (Author/EB)

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Engineering Sciences in Today's World

Hans Leussink

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Occasional Paper Number 16

Engineering Sciences in Today's World

Hans Leussink

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FOREWORD

There is great deal of fruitless discussion about the value of comparative studies in higher education. But there can be little disagreement that occasionally a topic or a problem arises in such a manner that it clearly speaks to matters and issues that transcend the country of origin. Such a paper is this one presented here by the ICED.

Hans Leussink is an engineer by profession and an educational administrator by the dictates of fate. His clear-headed tough mind was early recognized for the leadership of German higher education and science. As president of the Westdeutsche Rektoren Konferenz, chairman of the Wissenschaftsrat, Minister of Education and Science, a member of the Senate of the Max-Planck Institute for Educational Research, and now a director of the Krupp and Volkswagen Foundations, as well as the peripatetic international consultant to Berthold Beitz of the Krupp Foundation, Hans Leussink has had and continues to have a full and useful life.

This is a translation of a paper delivered in German at the University of Karlsruhe in June 1975, on the occasion of the University's 150th anniversary celebration. It speaks of the current dilemmas of science and engineering that are clearly universal. The ICED is pleased to bring this important speech to it own special audience.

James A. Perkins, Chairman
International Council for
Educational Development

Engineering Sciences in Today's World

Such a general topic could be approached in numerous ways. However, it was certainly not the intention to consider the situation in the Federal Republic of Germany exclusively, but rather to go beyond our borders in today's world. Not only is this the only approach proper to the topic; but as a people so dependent upon the international exchange of goods–and thereby also upon intellectual exchange–we Germans should always at least make the attempt to consider the state of affairs in the rest of the world.

The Current State of the Sciences in General

First of all, the topic demands that engineering sciences be considered in a very general way, in their relationships to other fields; they are after all a part of the whole. They have their share in the fate of this sector of possible human activities. And here one must concede that when the situation is seen globally, phenomena contributing to a crisis situation have the upper hand at the moment. The student unrest of recent years, which has now diminished or is in the process of doing so, could be seen as the visible indication of this. The decreasing attractiveness of teaching and research, which finds expression in the taxpayer's growing unwillingness to provide the ever-growing means for these activities,

has its most painful effects on the internal situation in institutions of higher learning.

The German university, ever since the founding of the University of Berlin in 1810 (an institution whose basic philosophy was derived from many sources and formulated most pregnantly by Wilhelm von Humboldt), occupied a unique position as a model of excellence to be imitated in the world for over 100 years. For about 40 years, this has no longer been the case. The Anglo-Saxon university, which has preserved some essential structural characteristics of the medieval university, has in its American manifestation developed a far greater influence since the nineteen thirties. It would take quite some time to prove this claim with sufficient examples, and above all to trace the developments in the history of the mind which have led to such a result. For the moment, however, we must satisfy ourselves with the simple statement that such is the case.

Now no one should bemoan this development. Rather, one should regard the phenomenon with wonder and be proud of the fact that a relatively small people in the heart of Europe never really united politically for a long period, should have been able to achieve and maintain such a leadership position for as long as it did. It would have been actually unnatural for that position to be maintained forever. I at least am not going to develop an inferiority complex over the loss of first place.

And indeed many essential features of our classical university model have been assimilated by the American system. These are the three basic postulates of Humboldt:

1. that "in an institution of higher learning"—to use his words—"research must continually be carried out;"

2. that the state must guarantee academic freedom, that is, the freedom to teach and learn; and
3. that the university has a pedagogical task, i.e. "to deduce everything from an original principle. . ., and furthermore to lead everything toward an ideal; finally, to join that principle and this ideal in an idea."

Of these postulates, it is quite clear that the first, the unity or the connection of teaching and research, has been assimilated in American postgraduate education; this can be read today in any publication on the development of the American university system. Regarding academic freedom, at least the freedom to teach is likewise present in America. However, there is not much left of the task of an education as formulated by Humboldt in accordance with "neohumanism."

One of the most interesting explanations for the current difficult situation of science and research that I have heard recently is by Clark Kerr, the former President of the State University of California at Berkeley, a man highly respected in academic circles throughout the world. As is well known, he was fired in a civil rights dispute by Governor Reagan. In Princeton, Kerr said recently that the present serious problems in higher education are the result in large measure of its own unique successes in the postwar period; he made a number of points, a few of which I want to cite here:

1. The university system absorbed an immense flood of students. In many countries this led to the overtaxing of capacities in traditional institutions which were unprepared.
2. Universities helped to preserve freedom and conducted effective opposition against repressive political measures. (This is something that they have done

again and again, by the way.) The price they paid for this—perhaps this is even understandable—was decreased support from those in the public sector who were attacked.

3. As the number of people who had attended a university increased for a given age group, the special social status conferred by the possession of a degree decreased; thus the impetus to attend became less inasmuch as elitist benefits were replaced by what the Americans call "meritocracy," that is, the domination by those who deserve it by having personally accomplished something eminent. In any case, the percentage of attendance by male students in America is on the decline.
4. Blue-collar workers trained in trade schools earn just as much as the white collar workers who have completed a traditional academic education. Thus the investment in a university education does not pay off financially. Kerr mentioned the fact that "sanitation workers" in San Francisco are earning one and one-half times as much as an assistant professor at Berkeley.
5. In the course of their explosive development, modern natural sciences and technology have made possible such apocalyptic devices as the atomic bomb. Of late it seems that biological manipulation is no longer out of the question. In general the feeling is increasing that science could constitute as great a danger to humanity as it does a benefit.

Some parts of this description are already applicable today to our own situation in Germany. Other parts will probably become acute for us in several years, given the usual phase lag.

In general, Kerr concludes that his statements are least relevant for engineering studies, that there the development is

steadier and takes place with fewer abrupt leaps than in other fields.

Engineering Sciences in the Cosmos of all Fields of Higher Learning, Particularly in their Relationship to the Humanities (Geisteswissenschaften).

In Volume 15 of the journal *Fridericiana*, the Jubilee Volume, there is a series of interesting and to some extent quite novel observations on the special place of engineering science in the overall context of higher learning; here a historical treatment was done by Messrs. Bussmann, Neumaier, and Rumpf, and a treatment of science theory was offered by Messrs. Lenk and Ropohl.[1] These colleagues get right down to the essence of the matter. I recommend very much that anyone interested in this topic read these studies. Allow me to add just a few remarks to what is contained in that volume.

At the beginning of our century the classical German universities, with their orientation toward the cultural sciences, accomplished—as you know—the unique historical feat of forcing the Technical Universities (*Technische Hochschulen*) to have their Ph.D. graduates write their Dr.-Ing. (Doctor of Engineering) titles in Gothic rather than Latin letters. Today we can only laugh charitably at this: what happened really was that a German engineering degree, as was the case with the designation "made in Germany" which was required to be put on products once considered inferior to British wares, soon came to be regarded as a sign of quality.

[1] Walter Bussmann, Klaus Neumaier, Hans Rumpf, Hans Lenk, and Günther Ropohl. *Fridericiana*, Volume 15, appeared in December 1974.

And also the old arrogance of the speculative (*räsonierende*) intelligentsia—here I am borrowing a term read recently in a piece by a philosopher[2], which, cloaked in a new extremely esoteric language, "appoints itself the ideological leadership elite, privileged to indulge in intellectual reflection," will not bother us engineers who are dismissed as "doers" (even some politicians are so designated nowadays). After all, we do not really think that everything is doable. But those of us who know their business are at least aware of what *is* doable, and what is not—in contrast to the worthy visionaries.

Thus I have never been bothered at being called a technocrat, or when people say that I do things technocratically. Of course technical activity, including engineering science, must continually be questioned. However, it must seriously be doubted whether the real key to the solution of our problems is offered by people like Jürgen Habermas, who demands "the public, unlimited and democratic (free of supremacy) discussion, of activity-oriented principles and norms at all levels of the political or still to be politicized process of forming of willpower."

After all, this has been tried often enough in recent years. With what results? For example, I can imagine that we would have spared ourselves much wasted energy had we followed more closely the structural model for universities which was recommended by the Scientific Council (*Wissenschaftsrat*) in November 1968. But this model was rejected as "technocratic;" the ostensible reasons were that it provided for a "restrictive regulation of access to higher education, an insufficiently open process of forming of the willpower, an asymmetrical double rule of academic representatives on the

[2] Lübbe, "Wie fortschrittlich ist der Fortschritt noch" ("How Progressive is Progress Today"), *Frankfurter Allgemeine Zeitung*, No. 27, Feb. 1, 1975.

one hand and presidents reinforced by extrauniversity power on the other, and finally a mediation over the university by social forces which have not been democratically legitimized." Meanwhile, however, actual practice is approaching this denounced model more and more.

The statement by Kerr just cited, that the development in engineering studies has been steadier than in most other fields, also corresponds to the observations that one can make on the German scene. Even a reference to such a seemingly superficial phenomenon as the development of numbers of students in the engineering faculties of our university confirms the tendency.

The total number of students increased by approximately 4000 in 1950, 6000 in 1965, and 10,000 in 1975; in other words, from 100% to 150% to 250%. The total of engineering students, on the other hand, increased by 3000, 4000, and about 4,700, or 100%, 130%, and 160%. Thus between 1965 and 1975 the total of engineering students increased only one-third as much as that of all students.

Another example: Despite the same law governing higher education in Berlin (*Berliner Hochschulgesetz*) in both cases, one has never heard of graduates of the technical faculties of the *Technische Universität* being rejected by potential employers simply because they studied in Berlin—as opposed to graduates in some fields at the Free University.

Engineering and the Natural Sciences

Concerning the relationship between engineering and the natural sciences, I believe that one can discern an increasingly close affiliation and an ever-better mutual understanding. Of

course the determining factor in the natural sciences still remains the orientation toward pure knowledge, while the engineering sciences are concerned primarily with that which is technically possible to accomplish.

I hardly need to mention in this context that the natural sciences could not work at all, for example in radio astronomy or outer space research, without the complex electronic measuring devices which in turn were first developed on the basis of results of pure research in semiconductors and especially solid state.

But consider, for example, plasma physics as conducted in Garching: what is natural science here, and what is engineering? Is the goal here more an increased knowledge of this peculiar aggregate state of matter, or is it more the fusion reactor as a new source of energy? What is this relationship in our centers of atomic research? Is modern oceanography primarily biology, or is it engineering? Does modern rock mechanics belong more to basic geological or geophysical research, or is it chiefly a means for avoiding catastrophes in the construction of dams and tunnels? Where does one assign communication science—to mathematics or to engineering? Will the Space Lab serve one area more than the other, or perhaps both at the same time?

I believe that posing such questions is becoming more and more fruitless. To the designation "engineering sciences" as applying natural sciences, one can today oppose—at least in a number of disciplines—the term "natural sciences" as pure research whose limits are, however, determined by the possibilities developed through the engineering sciences.

Obviously the natural sciences still retain a sort of pioneering role. The process of rapprochement between the

two areas is evidenced in engineering at times by an especially strong emphasis on a scientific orientation (*Verwissenschaftlichung*)–perhaps one should say an orientation toward the *natural* sciences (*Vernaturwissenschaftlichung*)–and by a concentration on mathematics and analysis. This was the case in the post-Sputnik period. Then, however, more attention is again paid to that which uniquely characterized engineering, namely synthesis, the feeling for sound construction in the building of machines and large architectural structures, the systematic-analytical relationship in the infrastructure and energy outlays of civil engineering or in the communications field of electronics.

It would seem forced if I were to attempt to maintain an absolutely discrete division between the natural sciences on the one hand and engineering on the other. Without disparaging the "pure" natural sciences, therefore, most of what has been said applies to both, and–unavoidably–even beyond them to include the totality of modern science, especially as far as the teaching aspect is concerned.

University Systems Outside Germany

Significantly, the doubt concerning the educational value of the natural sciences–or, even worse, of engineering–in Germany, as documented by my colleague Ruppel in the Jubilee Volume of *Fridericiana* already mentioned, has never been so strong in other industrialized nations.

It is true that in the French system of higher education, the natural sciences and engineering also developed outside of the universities–but more for the opposite reason. Napoleon dispossessed the old universities, depriving them above all of their research function; he made the newly created *Grandes*

Ecoles into the most important and respected institutions. In large measure they formed the ruling elite of the country, and they continue to do so today. One of the most important of these, then and now, was the *Ecole Polytechnique* founded in 1795 in Paris, which was the sponsor at the founding of our institution in Karlsruhe.

Regarding the American university, one must first of all state that there is no such thing as *the* American university. Of course there are some common basic characteristics among the institutions in this highly differentiated—in quantity and quality—system. First of all there is the medieval faculty of arts, the liberal arts college. This institution, as opposed to our system, has retained much of its original function. Usually it leads to a Bachelor's degree in four years; one matriculates at age 17 or 18. It provides a general education, as well as a more specialized training—one that we sometimes very unjustly denigrate.

The land-grant universities came into being through the Morrill Acts of 1862 and 1890. They provided the American university system with another special characteristic, one that became especially significant for engineering studies. These never had to struggle for recognition, and there it was never questioned that so-called social relevance is a legitimate demand on the universities—even though this is by no means the exclusive criterion for their existence.

This structure has a traditional track of four years of undergraduate study terminating with the Bachelor's degree, which satisfies the vast majority of students, and the subsequent postgraduate study ending with a Master's or Doctor's degree. Such a setup proved to be astoundingly flexible and adaptable in the era of the rapid transition from the elite university—this was also true of the American

university at one time—to the mass university stage, where we Germans are at the moment, and finally to the system of universal college education, where entrants amount to more than 50% of a respective age group. One of the reasons for this is certainly that in principle no stage in the track signifies an absolutely final termination of study.

When one also considers the recent American development of two-year junior colleges, together with a mode of instruction which is much more like that in secondary schools than is the case with us, as well as an entrance procedure which varies greatly with the individual institutions, then it becomes evident that we are looking at a tertiary educational system which was clearly capable of absorbing the mass demand for education; it is able to conform to rapidly altering needs; it knows no dead ends; and it bridges optimally the ultimately irreconcilable antagonism between social need and individual demand.

This basic American structure, evident in the more than 2,500 institutions of the tertiary educational system, applies—except for medicine—to the humanities and social sciences as well. However, it developed primarily in response to the needs of the technical fields and the natural sciences.

I will pass over the British system, which, although it demonstrates some departures, is still the mother of the American system and has the same basic structure. In contrast with the development in our country engineering studies have only recently established themselves in special institutions, the Colleges of Advanced Technology (CAT). This term could be more or less directly translated by the German *Technische Hochschule*. Formerly engineering was taught exclusively in the traditional universities, including Oxbridge.

The situation in the Soviet Union is characterized by some overemphasis of technical specialties. Here one gets the impression that a onesidedness dominates which is similar to that once evident in Germany—only this time it is the opposite pole, the technical fields, which get all the attention. This can be seen for example in Akademgorodok, the research settlement of the Soviet Academy of Science which is east of the Urals near Novosibirsk; here one can experience a very intimate symbiosis between the natural sciences, mathematics, and engineering. Also significant is the high esteem in which engineers and natural scientists are held in the Soviet Union; the political leadership elite consists in large measure of people with training in engineering.

Educational Systems Adapting to Modern Needs

Technological and scientific factors which are contributing to the ever greater complexity of modern life can certainly be dealt with more easily in a flexible system than in one which is rigid. This demand for flexibility and differentiation is demonstrated most clearly in that area where modern life is formed, but where technology must simultaneously be brought under control. This is especially true in engineering sciences. Until a few decades ago, this demand was met in a manner which has always been admired throughout the world, in the splitting up of our system of technical education into training as apprentices in the trades and in industry, schools for technicians, engineering schools (*Ingenieurschulen*), and the engineering faculties at the *Technische Hochschulen* and universities.

Unfortunately this system, which for so long functioned as a model to emulate, had two drawbacks which became more

and more serious. On the one hand, it was not flexible enough in itself; also, it was not open enough for transitions from one step to the next, or from one field to another. Each step was in principle closed off from the others. This was most evident in the two highest stages, the engineering schools and the *Technische Hochschulen*.

Well, this in itself perhaps would not have been such a source of dissatisfaction. However, the discrepancies in prestige between the various levels were and are matched by very great differences in material compensation. This is essentially a consequence of the hierarchy of careers in state service, something which is almost impossible to understand rationally. The state, though, is for us a determining factor in the formation of the entire society; this is perhaps more the case with Germans than with any other people.

But it is senseless to try to change something significantly at the beginning of the chain leading from training to a profession, namely in school and in higher education, while leaving everything the same at the other end, in the professions.

Therefore I am becoming more and more convinced that all educational reform—at least in the areas hinted at here—is in vain if the state is not prepared to alter its civil service regulations; after all, the educational system has hitherto conformed exactly to these regulations. The outlook is bleak, however.

Pessimism is the only possible outlook here. This is confirmed by my own experiences with the Federal Ministry of the Interior in Bonn, by recent statements from authoritative sources in the Federal Government, as well as the predictable behavior of the legislative branch in this area,

especially the *Bundestag*. This civil service system, which penetratingly reeks of the medieval guilds, will be very difficult to change in any way. And whenever the parliaments make even the most moderate suggestions aimed at cautiously loosening up the system, the bureaucracy in the executive branch offers massive resistance; this could recently be observed in Stuttgart, the capital of Baden-Württemberg.

It may be painful for those affected. But doing away with an elitist educational system in schools and universities also means doing away with the guarantee of employment and compensation. Unfortunately, one cannot have it both ways: on the one hand a mass educational system with its greater equality of opportunity, and at the same time the guaranteed coupling of the training system and professional success of the elitist system. Indeed, equality of opportunity means a greater risk.

As is well known, an initial, well-thought-out proposal to get some much-needed flexibility into higher education—and here one was thinking especially of engineering science—was made in 1966 and 1967 here in Baden-Württemberg under the aegis of my colleague Wilhelm Hahn*; this was the *Gesamthochschule* (comprehensive institution of higher learning) Project. This was one of the few original German ideas which has stimulated great interest and attention in the international academic community since the end of the war. On the other hand, one could perhaps look at the matter a bit less amiably and term it an attempt to adapt our system to that in the United States, which is now the pacesetter for the world.

*The present Minister of Cultural Affairs in Baden-Württemberg.

Such attempts at adaptation are widespread, by the way. Various French proposals for training in engineering—unlike the German ones, it was possible to actually carry them out—could also be viewed thus. This is so whether we look at the *Insa's* the *Instituts Nationeaux des Sciences Appliquées* which were inaugurated by Jean Capelle in the 1950s (indeed, our oldest partnership at Karlsruhe is with such an Institute in Villeurbonne near Lyon), or at the more recent two-year courses of the *Instituts Universitaires de Technologie*, which since 1966 have been set up at French universities.

The Japanese system of higher education, which at first was strongly influenced by Central European systems, not least by the German, has also clearly turned toward the American system since the last war.

It is significant that in the course of further discussion of the *Gesamthochschule*, there was first of all a controversy over the quite dogmatic question of whether it should be "integrated" or "cooperative;" and the question of teachers' salaries, level H4 versus H2, plus that of the payment of graduates in state employment, level A12 or A13 or even higher, shone forth all too clearly from behind camouflaging questions of status. It is further characteristic of the situation that in the overall educational plan of 1973, of the Federal-State Commission for Educational Planning, the proposal of the Scientific Council to set the share of the short form of study (i.e., one lasting about three years) in a comprehensive system of higher education at about 15-18%, whereas the long form (4-5 years of study) getting 5-6%—together these would thus account for about 25% of an age group—was almost turned completely around by the Federal-State Commission (*Bund-Länder Kommission*) because of the inhibitions just mentioned. Now the short form is to make up

about 8% and the long form 16%, amounting to 24% of an age group. From the standpoint of all systems of higher education with consistent consecutive differentiation, this is anything but a rational proposal.

Meanwhile, as is well known, a series of *Gesamthochschulen* have been set up in the Federal Republic. Also, the higher education complex in and around Karlsruhe is supposed to be joined soon into a cooperative *Gesamthochschule* according to legislation in the state of Baden-Württemberg. Let us hope that in this project, unlike so many other measures taken in recent years, a complication of matters and a waste of resources can be avoided and that the most pressing problems, above all in the area of teaching, move at least a step nearer to a solution. This at least would be my desire on the 150th birthday of this school which has been so successful up to now.

Evaluation of the Current Situation

How can the present state of our engineering sciences be characterized?

To begin with the positive side: Parallel with the development in the natural sciences, research has again reached a remarkably high level. The pessimistic projections of the former president of the German Research Council (*Deutsche Forschungsgemeinschaft*) in 1964 concerning research[3] have meanwhile—thanks to God as to the *Forschungsgemeinschaft* itself—become outmoded.

[3]Gerhard Hess, "Stand und Rückstand der Forschung in den Natur-und Ingenieurwissenschaften," Steiner-Verlag.

This statement is supported, for example, by the great popularity which the standard Research Scholarship Program for Foreigners administered by the Alexander von Humboldt Foundation shows in the engineering fields as well as in others. This is increasingly the case for applicants from highly industrialized countries such as the United States, England, and Japan. It is perhaps even more significant that the Federal Government's U.S.-Senior Scientist Program (also administered by the Humboldt Foundation) has of late proved very attractive to extremely well-qualified American engineers.

Unfortunately, the situation in the teaching area does not permit such positive statements. Criticism here does not really apply so much to the *content* of academic instruction; considering the high level of research just pointed out, this cannot be that bad. No, what must be faulted here is the overlong duration of the course of study, something which is simply incomprehensible to the rest of the world—except perhaps in some parts of South America.

That we permit ourselves to waste two or three years of youthful creativity, in that the overwhelming majority of graduates in higher education, including the majority of engineering graduates, do not complete their education before the age of 25 to 27, is coming to be regarded as absurd by the rest of the world. If we were not so successful in other areas—be it in the area of social security for all, or in the production of goods for worldwide export, to name only two—then one could get the impression that we Germans were the stupidest people of all.

Is this a sort of luxury that we grant ourselves in this matter? But is this a positive luxury, as those who point to the achievement of general freedom of study would have us

believe? I venture to express my doubts here. Indeed, I am very skeptical about whether it is so beneficial for the self-development of young people that about ten years elapse after they attain their majority before they begin to bear responsibility, to work creatively, and to stand on their own two feet. That we permit ourselves this unproductive waste is no source of self-congratulation for all those concerned: past and present educational policy makers; Ministers of Education; legislators; teachers in higher education; students; and institutions. Apparently not one of those involved is capable individually of getting things moving in this encrusted state of affairs. In their interaction the elements of this entangled system of incorrigible conservatism, ideological obfuscation, excessive concern for the prevailing political climate, laziness, and indeed irresponsibility, checkmates and condemns itself to immobility. Will the participants come to their senses only when economic growth begins to slow down, or even when a crisis occurs? And will the finance ministers finally deal with the situation by cutting the Gordian knot, directly or indirectly? A baleful prospect, that.

So should we rather naively adopt the U.S. educational system, if it is obviously more flexible and easier to differentiate? If only it were that simple! Merely adopting that which is immediately apparent in the American system, namely the structure of courses of study, would not be enough. And adapting instruction methods increasingly to those in the lower schools would not help much either.

At least two more essential ingredients would have to be added: First, we would have to bid farewell to the prevailing ideology that in principle all institutions of higher education are qualitatively equal. And then one would have to concede to the institutions a measure of real autonomy regarding their inner and outer structure—especially financial autonomy such

as that possessed even by state universities in the United States as well. This would mean that the universities would be provided also with a corresponding administrative structure and power–in the sense of a university president supported by extramural powers, that phenomenon so condemned by some–as well as control by forces which have not been democratically legitimized.

Well, if we had all these conditions, we would not be in the situation in which we find ourselves at present. But tradition plays a large role, especially so glorious a tradition as that possessed by us. Thus we shall have to go our own way; it will be long and difficult. For the moment, however, we shall not be able to make the same positive statements about our system of academic instruction as we can about our research establishment and let us hope that the research operation will not be influenced negatively by the teaching situation.

Exporting the University System

What should one do when one wants to export engineering studies with a German orientation and in the German language to developing countries which are developing very fast?

First of all, considering what has previously been said, it is rather astounding to see that we are wanted at all in this business. But we can rejoice, for as it is in the future we shall nevertheless be more dependent on the export of brain power than of hardware.

Our worldwide reputation as a reliable provider of industrial commodities of all kinds and of high quality is unchanged. And without a corresponding high level of

research and development, successes in this field would not be possible.

Compared with English, it is true that German is not a world language; and it is certainly not a lingua franca of natural science and engineering. Still, many important scientific publications, technical reports and standards do appear in German. Because of a lack of time and personnel, the developing countries see no possibility of translating the literature important to them into their own language, for example Arabic or Farsi. But they do want to have a sufficient number of people in their leadership circles who are not only capable of reading relevant German publications, but who are also able to follow the thought patterns which lie behind them. Futhermore, it is certainly also important that they want to be able to choose between more alternatives. In fact we find ourselves in this context dealing with the same competitive forces which we also meet in the international exchange of goods.

How would such an export look in practice? Externally, the course of study would have the consecutiveness and flexibility of the American system; there would be a rational admission's procedure, a period of four years of study ending with a professional qualifying examination. Then would come further study with emphasis on research until the second termination or the doctoral degree. In the first stage, the course of study would be strictly regulated.

What we Germans would bring as our unique contribution is the research aspect. But this is difficult to put into practice as long as the country has no extensive self-initiated industrial development. For research one needs a critical mass as well as a certain attitude. The quantitative problem of critical mass can be taken care of relatively easily by bringing in the necessary research personnel from Germany. The

qualitative problem of the proper favorable atmosphere is much more difficult to overcome. In engineering research—as in natural sciences—technical personnel such as laboratory technicians and foremen are extremely important; aside from this, however, *ideas* must also be present. It is well known that the spirit goes where it wants to—but only there.

Here one will have to come up with something, for example departmental partnerships which will facilitate a continual stream of ideas. But this cannot become a one-way street; from the very beginning it must be done with a view toward equal participation. Also, one could consider getting German industries to assign tasks in applied research to universities in the countries to which they export products.

The expectations for such a German-oriented institution of higher education go far beyond the mere exportation of technical knowledge and expertise. One would tacitly expect at the same time to be able to import certain character traits that people ascribe to us Germans. To put it somewhat bombastically, people speak of the Faustian side of the German character. What is meant, to put it rather more soberly, is that we do a thing for its own sake; that we show a certain devotion to a project, one that is not motivated by material interests alone; and that consequently we carry something to its conclusion rather than capitulating at the first serious difficulties.

Of course only the general educational system can find and develop such qualities if they are to be implanted in the character of people. To a great extent university training between the 18th and 23rd years of life cannot do this. Thus we will have to pour much water into this wine.

Here, however, is another reason to add to the many others for considering that the goal cannot be merely a

technical university consisting only of faculties of engineering and natural science. Merely the necessity of taking the German language *and* the native language beyond the purely instrumental level, to consider their intellectual contents, their cultural background and their historical development, provides a natural impetus for establishing a complex of humanities (*Geisteswissenschaften*). Architecture, which after all does not see itself exclusively as engineering, and which—although it has played an essential role in Karlsruhe ever since its founding 150 years ago (and which I have been guilty of neglecting until this moment)—should also be included in such deliberations early on.

Summary

Allow me to summarize briefly: Engineering sciences, which have always been a key element in our university, are subject—if to a lesser degree—to the same tensions and frictions affecting all fields of higher learning, here and abroad.

The quality of research can be unhesitatingly characterized as satisfactory.

The same cannot be said of academic teaching. Here one will not be able to simply copy the American system. But the principles of great flexibility, diversification, and efficiency, which are optimally present in the American system and facilitated the transition to the mass university, will also have to be implemented in some form in Germany.

There must be a severance between civil service regulations and the educational system, even though this be painful because of the horizon of expectations fostered by their present coupling.

Our engineering studies, together with related sciences, still enjoy—or now enjoy again—such a worldwide reputation, that other countries desire to import them.

Perhaps a hope can be derived from this. Perhaps daily contact with a very different environment will also provide additional impetus for us to make whatever changes are necessary in our own system. So, with this in mind, let us accept the challenge!

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